

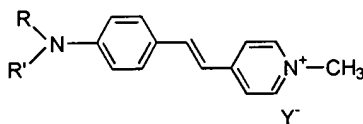
## Clean Version of Changes

Mirrorless solid-state lasing devices are also disclosed which are constructed using the dipolar organic salts doped into solid matrices of poly(methyl methacrylate) (PMMA).

- 5 Spectrally narrowed directional emission with typical bandwidth of ~10 nm is achieved.

The present invention has the following characteristics:

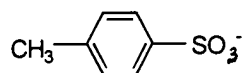
- 10 1. A dipolar organic material producing highly efficient laser-like emission at low thresholds without external mirrors.
2. A highly efficient and low-threshold mirrorless lasers (producing laser-like emission without mirrors) comprising:
- 15 (a) organic materials producing highly efficient laser-like emission at low thresholds without external mirrors in solution as active media; and
- (b) a pump laser projecting the excitation beam into the active media.
3. These organic molecules have large dipole moments as active media.
- 20 4. These dipolar organic molecules are dyes which have large photoluminescence efficiencies as the active media.
5. These strongly dipolar organic molecular salts have the following chemical formula as the active media:



where  $R$  and  $R'$  are the same or different, and comprise a moiety selected from the group consisting of alkyl, substituted alkyl, benzyl, and substituted benzyl, and  $Y$  is an anion.

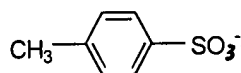
6. One of the preferred salts is where both  $R$  and  $R'$  are  $-\text{CH}_3$ , and  $Y$  is  $\text{CH}_3\text{OSO}_3^-$ .

5 7. Another of the preferred salts is where both  $R$  and  $R'$  are  $-\text{CH}_3$ , and  $Y$  has the following formula:



8. Another of the preferred salts is where both  $R$  and  $R'$  are  $-\text{CH}_3$ , and  $Y$  is  $I^-$ .

9. A further preferred salt is where both  $R$  and  $R'$  are  $-\text{CH}_2\text{CH}_3$ , and  $Y$  has the following formula:



10. Dipolar organic dyes, such as rhodamine 6G (R6G) and DCM, have large photoluminescence efficiencies as the active media.

11. A pump laser is used at a wavelength where the active material has strong absorption.

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12. A pump laser emitting optical pulses having pulse width shorter than the duration (about  $<100$  picoseconds) of the excitation pulses is preferred.

13. A pump source producing 1-100 picosecond pulses frequency-doubled by a nonlinear optical crystal such as potassium dihydrogen phosphate (KDP) is preferred.

14. The mirrorless laser preferably has threshold excitation pulse-energy less than about 1 microjoule with a line excitation of about 5 mm<sup>2</sup> area.

15. The mirrorless laser preferably yields energy conversion efficiencies of more than about 15%.

16. The mirrorless laser may yield energy conversion efficiencies of up to about 40%.

17. The mirrorless ultraviolet short-pulse emitting laser of this invention is preferably constructed by frequency-doubling the output of the laser using a nonlinear optical crystal such as  $\beta$ -barium borate (BBO).

18. A mirrorless laser emitting picosecond pulses at 300-310 nm may be constructed by frequency-doubling the output of the lasers.

19. The mirrorless lasers of this invention are stable under continuous operation for at least about 5 million shots.

20. The mirrorless solid-state laser may be constructed using strongly dipolar organic molecules doped into solid polymeric matrices.

21. The mirrorless solid-state laser may be constructed using the dipolar organic molecules doped into solid matrices of poly(methyl methacrylate) (PMMA).



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## References Cited

## OTHER PUBLICATIONS

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- a 2. H. Brouwer, V. V. Krasnikov, A. Hilberer, J. Wildeman, Appl. Phys. Lett. **66**,  
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3. D. Moses, Appl. Phys. Lett. **60**, 3215 (1992).
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